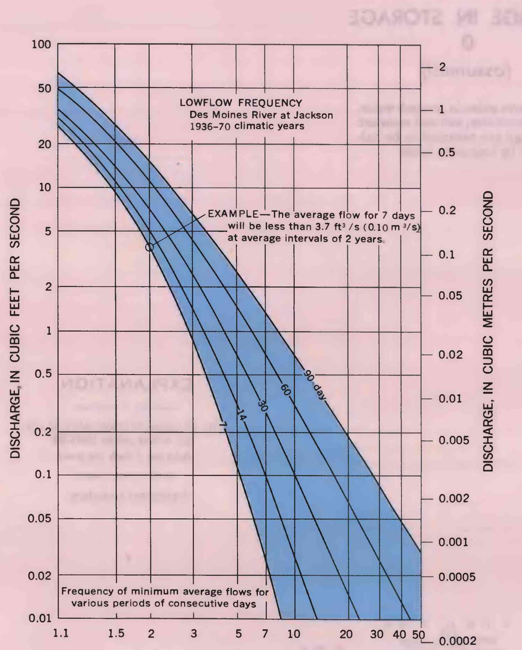
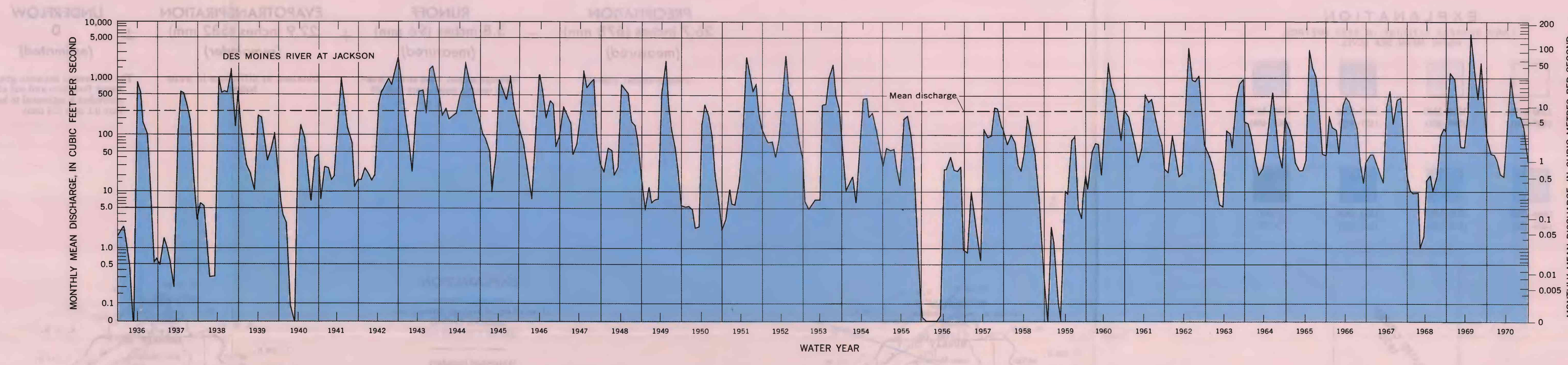
PREPARED IN COOPERATION WITH THE
MINNESOTA DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATERS, SOILS, AND MINERALS

SURFACE WATER

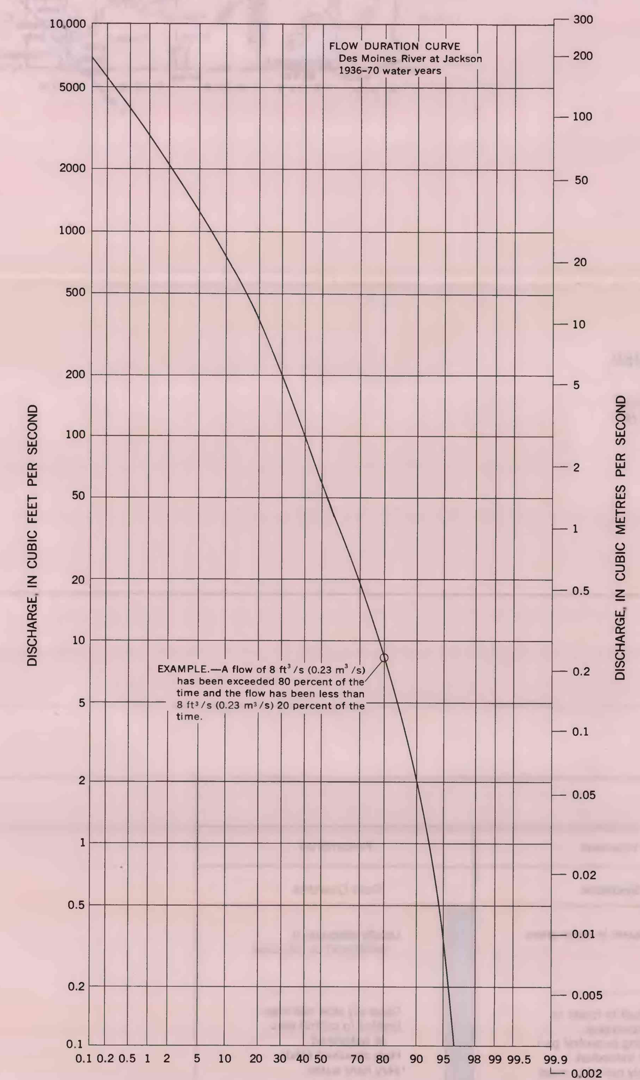
Variations of streamflow affect the suitability and quantity of water available for various uses. Consideration of magnitude, frequency and time of occurrence, effects of streamflow upon quality, and the duration of streamflow variations are necessary for the evaluation of surface-water resources.



KNOWLDEGE OF LOW STREAMFLOW AND ITS FREQUENCY OF OCCURRENCE IS VITAL IN THE ECONOMIC DESIGN OF WATER-SUPPLY, POLLUTION-ABATEMENT, AND RECREATIONAL-DEVELOPMENT PROJECTS.—*Low-flow frequency curves reflect geohydrologic conditions and indicate the contributions to streamflow from ground-water sources. With a combination of low lake levels and very little precipitation, the Des Moines River and its tributaries recede to relatively low flows. Streamflow records indicate that periods of no flow are common during late summer, fall and winter months, indicating that some aquifers do not readily transmit water to the streams, and other aquifers are depleted from lack of recharge, or contained only small quantities of water.*



FLUCTUATIONS IN STREAMFLOW ARE CAUSED BY VARIATIONS IN PRECIPITATION AND TEMPERATURE.
The highest streamflow is generally in spring and results from snowmelt and spring rains, followed by a recession in flow through late summer, fall, and winter months. However, the highest flows of 1942 and 1963 occurred as a result of excess precipitation in late summer. The highest monthly mean discharge was in April 1969 and was attributed to an exceptionally heavy blanket of snow. Deficient precipitation and winter freezeup caused a number of months to register no flow. The longest period of no flow occurred from October through January of the 1956 water year.



THE FLOW-DURATION CURVE FOR THE DES MOINES RIVER AT JACKSON IS A CUMULATIVE FREQUENCY CURVE.—*It shows the percentage of time that specified discharges were exceeded during the period of record. The percentage of time that flow was less than a specified amount can be obtained by subtraction.*

The large lakes in the basin play an important role in flow of the river. Snowmelt, spring rains, and intense storm runoff are absorbed by the lakes. Flow peaks are reduced in magnitude and high flows are prolonged as the lake water is released from storage. This accounts for the moderate slope of the curve in the high range. The steep slope beyond the 80 percentile is primarily a result of little or no flow owing to low lake levels. At this time most precipitation in the lake basins goes into storage, replenishes soil moisture and satisfies evapotranspiration demands.

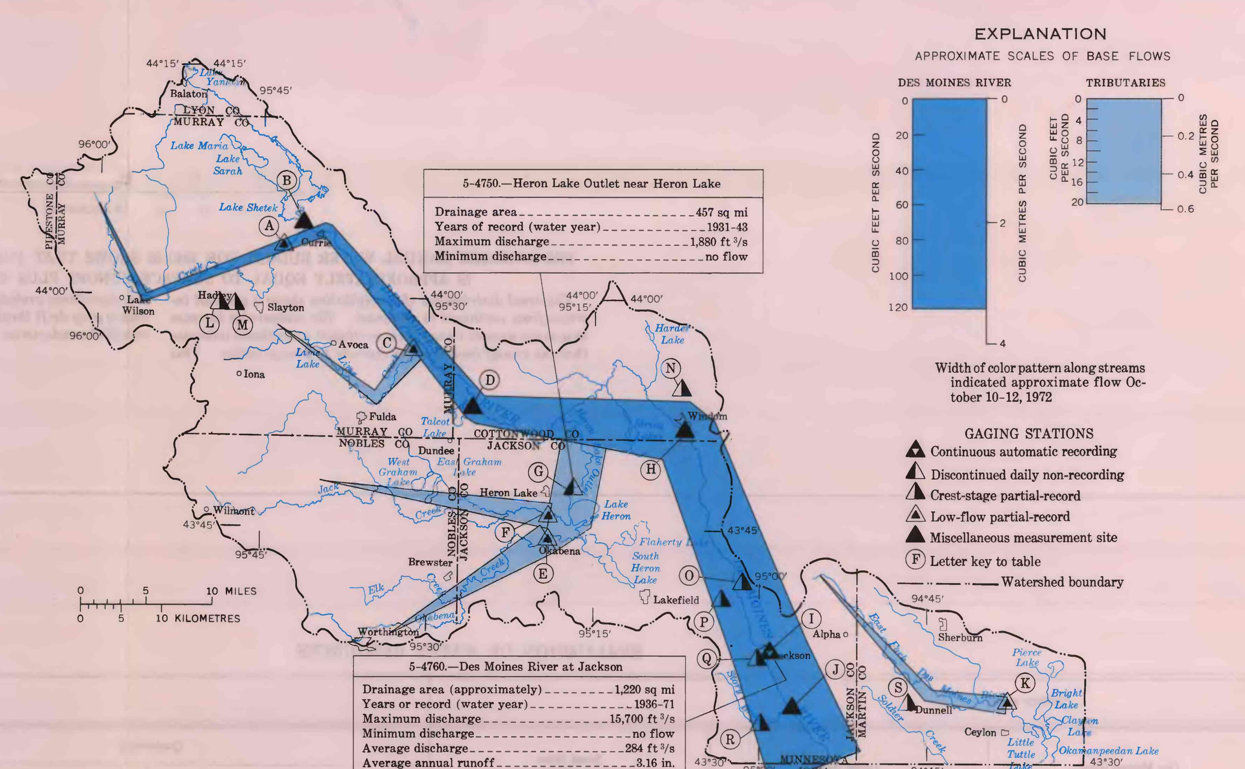
CREST-STAGE PARTIAL-RECORD STATIONS

Letter key	Number	Gaging station name and location	Drainage area (square miles)	Years of record (water year)	Discharge (ft^3/s) Maximum	Minimum
L	5-4747.5	Beaver Creek tributary No. 2 near Slayton	5.10	1961-71	211	No flow
M	5-4747.6	Beaver Creek tributary above Slayton	2.20	1961-71	157	No flow
N	5-4754	Warren Lake tributary near Windom	1.38	1960-71	260	No flow
O	5-4758	Des Moines River tributary near Jackson	1.42	1960-71	104	No flow
P	5-4759	Des Moines River tributary No. 2 near Lakefield	4.52	1960-71	271	No flow
Q	5-4760.1	Nelson Creek at Jackson	4.80	1959-71	2,690	No flow
R	5-4761	Story Brook near Petersburg	25.2	1960-71	2,500	No flow
S	5-4769	East Fork Des Moines River tributary near Dunnell	7.88	1960-71	2,390	No flow

DISCHARGES DURING BASE FLOW PERIOD

Letter key	Station number	Gaging station name and location	Ft^3/s
A	5-4747.7	Beaver Creek near Currie	6.65
B	–	Lake Shetek Outlet at Currie	<.30e
C	5-4748	Lime Creek near Avoca	2.84
D	5-4748.6	Des Moines River below Talcott Lake, near Dundee	16.0
E	5-4749.2	Okabena Creek at Okabena	3.09
F	5-4749	Jack Creek near Heron Lake	4.60
G	5-4750.8	Heron Lake Outlet near Heron Lake	3.37
H	–	Des Moines River at Windom	34.8
I	5-4760	Des Moines River at Jackson	44.0
J	–	Des Moines River below Jackson	45.8
K	5-4769.9	East Fork Des Moines River near Ceylon	2.97

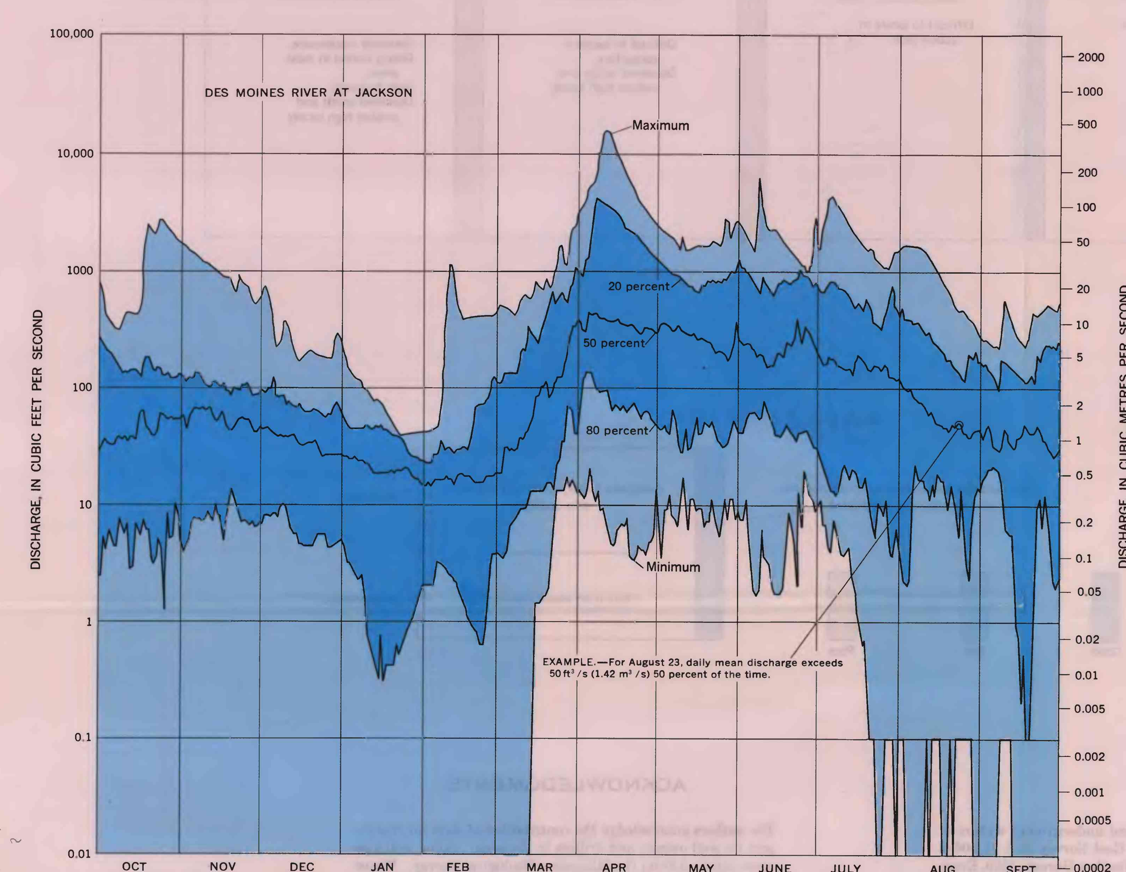
<–Less than e–Estimated



THE FLOW DIAGRAM SHOWS DISTRIBUTION OF STREAMFLOW IN THE WATERSHED DURING THE BASE-FLOW PERIOD OCTOBER 10-12, 1972.

Ground-water and lake storage were the major sources of streamflow during the base flow period. A series of discharge measurements was made to determine the distribution of surface-water resources in the watershed within the given time interval. Because there was no recorded precipitation for 5 days prior to this period, the streamflow measured represents base flow yield from the watershed. The flow duration curve for Des Moines River at Jackson, 5-4760 *indicated a fairly high base flow for this time of the year. The flow was at the 56 percentile on the flow-duration curve and had a 1.2-year recurrence interval on the 7-day low-flow frequency curve. The average flow of Des Moines River during this period was 0.54 ft^3/s per river mile (0.0095 m^3/s per river kilometre). In comparison the average flow of the East Fork Des Moines River near Ceylon was only 0.15 ft^3/s per river mile (0.0026 m^3/s per river kilometre).*

The base flow distribution pattern shown on the map is not stable, for it can be influenced by many factors such as season, distribution of antecedent precipitation, and condition of the ground surface.



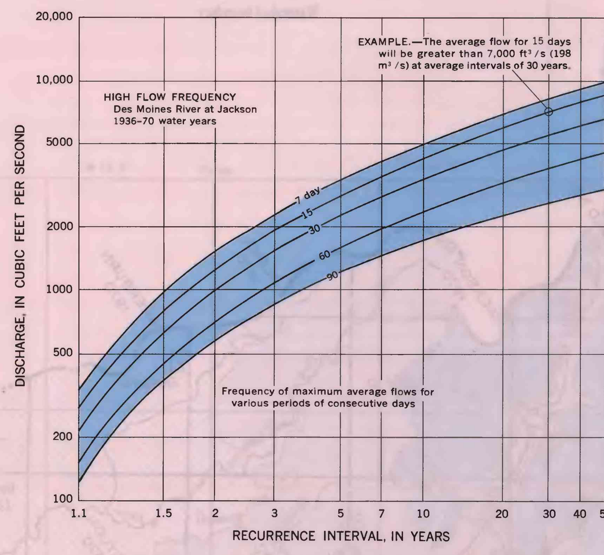
THE DAILY AND SEASONAL VARIATION OF FLOW IS SHOWN BY THE DAILY-DURATION HYDROGRAPH FOR DES MOINES RIVER AT JACKSON FOR 1952-70.—*The daily mean discharge for a given day can be determined from the hydrograph. For example, the minimum daily mean discharge for August 23 was 0.10 ft^3/s (0.0028 m^3/s). The daily mean discharge for August 23 exceeded 5.3 ft^3/s (0.15 m^3/s) 80 percent of the time; 50 ft^3/s (1.4 m^3/s) 50 percent of the time; 130 ft^3/s (3.7 m^3/s) 20 percent of the time; and the maximum was 446 ft^3/s (12.6 m^3/s). The lowest flows were in late summer, fall, and winter when periods of no flow were recorded. The highest flows were during the month of April, with a maximum of 15,500 ft^3/s (439 m^3/s).*

SELECTED LARGE LAKES

Name (County)	Surface area (acres)	Depth (feet) Maximum	Average	Outlet control	Fish and game classification	Remarks
String (Cottonwood)	402	8	—	Dam	—	Has public access. Habitat requirements for waterfowl or fur bearers are nonexistent. Open to promiscuous fishing some winters.
Talcott (Cottonwood)	928	6.5	4.5	Dam	Waterfowl-muskrat	Has public access. Recently stocked with crappie adults and northern pike fingerlings and yearlings and walleye fry. Lake controlled for roughfish.
Fish (Jackson)	464	6	3.5	Dam	Roughfish-bullhead	No public access.
Heron (Jackson)	8,251	5	3	Dam	Waterfowl-roughfish	Access possible through Division Creek. Fish rescue carried on each winter. Open to promiscuous fishing some winters.
Bright (Martin)	660	8	—	Natural	Minnow	Roughfish removed periodically. Open to promiscuous fishing some winters.
Clayton (Martin)	540	5.5	3	Natural	Roughfish-bullhead	Occasional fish rescue. Occasional removal of roughfish.
Okamanpeedan (Martin)	2,205	6.5	—	Dam	Minnow	Has public access. Occasional removal of roughfish. Open to promiscuous fishing some winters.
Pierce (Martin)	548	11	5	Dam	Minnow	Has public access. Open to promiscuous fishing some winters.
Maria (Murray)	425	3	2	Dam	Waterfowl-muskrat	Has public access.
Sarah (Murray)	1,176	—	—	Dam	—	Has public access. Recently stocked with walleye fry and northern pike fingerlings. Occasional removal of roughfish.
Shetek (Murray)	3,596	10	5	Dam	Warm-water game fish	Has public access. Continuously stocked with northern pike adults and fingerlings and walleye fingerlings. Fish rescue carried on each winter. Roughfish removed periodically.
East Graham (Nobles)	523	6	4.5	Dam	Minnow	Roughfish removed periodically. Open to promiscuous fishing some winters.
West Graham (Nobles)	526	8.5	8	Dam	Minnow	Has public access. Stocked with panfish as needed. Roughfish removed periodically. Open to promiscuous fishing some winters.

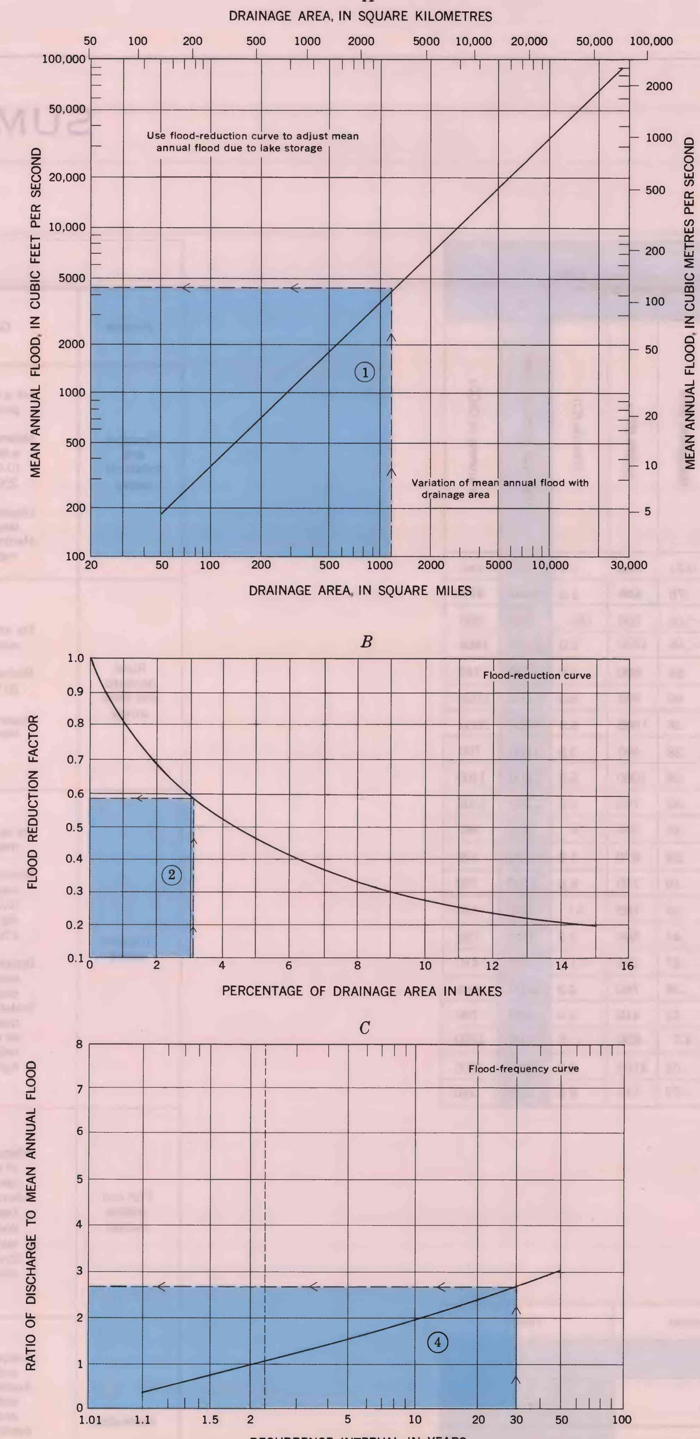
* Data obtained from Minnesota Department of Natural Resources.

SELECTED LARGE LAKES, ALONG WITH MANY SMALL LAKES, PONDS, AND WETLANDS IN THE WATERSHED ARE AN IMPORTANT ALL-SEASON RECREATIONAL RESOURCE.—*They provide fish and wildlife habitat and are used for hunting, fishing, water sports, and general vacationing. Although all the lakes are shallow they do provide panfish and warm water gamefish which are subject to winter kill almost annually. When this condition exists almost all the lakes are opened (by the Minnesota Division of Fish and Game) to unlimited fishing. The shallow, weedy waters are used by breeding and migrating waterfowl and make the watershed one of the better duck hunting areas in the State.*



HIGH FLOWS ARE INFLUENCED BY PHYSIOGRAPHIC AND CLIMATIC FACTORS.—*The high spring flows from snowmelt, augmented at times by rainfall, are not of a flashy nature in the Des Moines River watershed. Flow peaks have a rounded shape when graphed and are of long duration owing to the many large lakes. Runoff first goes into lake storage and then is released over a long period of time. This prolonged effect of storage is seen in the flat slope of the high-flow frequency curves.*

High-flow frequency curves are useful in the design of flood-control projects and in solving problems of reservoir design and operation. The curves show the average interval, in years, between which a specified high discharge for a preselected period may be expected to recur.



FREQUENCY AND MAGNITUDE OF FLOODS ARE RELATED TO DRAINAGE AREA AND PERCENTAGE OF BASIN IN LAKES.—*The magnitude and frequency of floods can be determined from the relation curves A, B, and C (Patterson and Gamble, 1968). These curves refer to streams within the Des Moines River Watershed.*

Example.—Find the magnitude of a flood that has a 30-year recurrence interval for the Des Moines River at Jackson. The drainage area at this site is 1,220 mi^2 (3160 km^2) and the area of lakes above the site is 3.1 percent of the total drainage area.

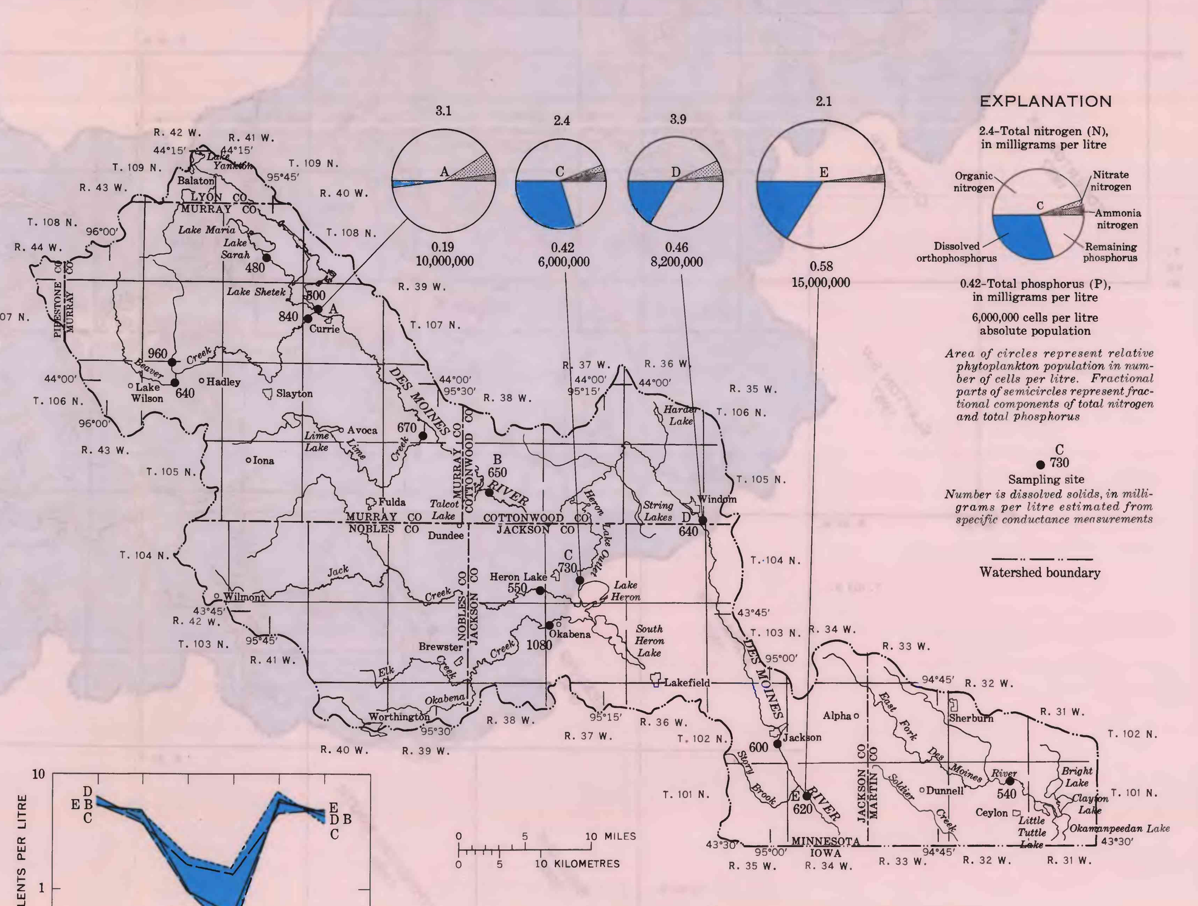
1. *Relation curve "A" shows that for a drainage area of 1,220 mi^2 (3160 km^2), the discharge for the mean annual flood is 4,400 ft^3/s (125 m^3/s).*
2. *Relation curve "B" shows that for a site whose drainage is 3.1 percent lakes, the flood-reduction factor is 0.58; thus, the discharge for the adjusted mean annual flood is 4,400×0.58, or 2,550 ft^3/s (72 m^3/s).*
3. *Relation curve "C" shows that for a 30-year recurrence interval, the ratio of discharge to the mean annual flood is 2.7.*
4. *Therefore, the magnitude of a flood that has a 30-year recurrence interval is 2,550×2.7, or 6,880 ft^3/s (195 m^3/s).*

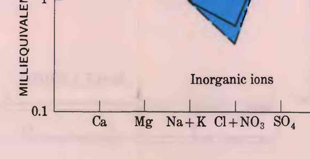
The recurrence interval of a flood of a specified magnitude at this same site can be found by reversed procedure.

WATER QUALITY

AT BASE FLOW OCTOBER 1972

Sampling site	Dissolved solids (mg/l)	Hardness as calcium carbonate $CaCO_3$ (mg/l) Total	Noncarbonate	Total nitrogen (N) (mg/l)	Ammonia nitrogen (N) (mg/l)	Nitrate nitrogen (N) (mg/l)	Organic nitrogen (N) (mg/l)	Total phosphorus (P) (mg/l)	Dissolved orthophosphorus (P) (mg/l)
A	500	—	—	3.1	0.10	0.36	2.6	0.19	0.01
B	650	510	280	—	—	.23	—	.13	—
C	730	500	320	2.4	.11	.04	2.3	.42	.25
D	640	510	300	3.9	.10	.41	3.4	.46	.15
E	620	460	210	2.1	.06	.00	2.0	.58	.18





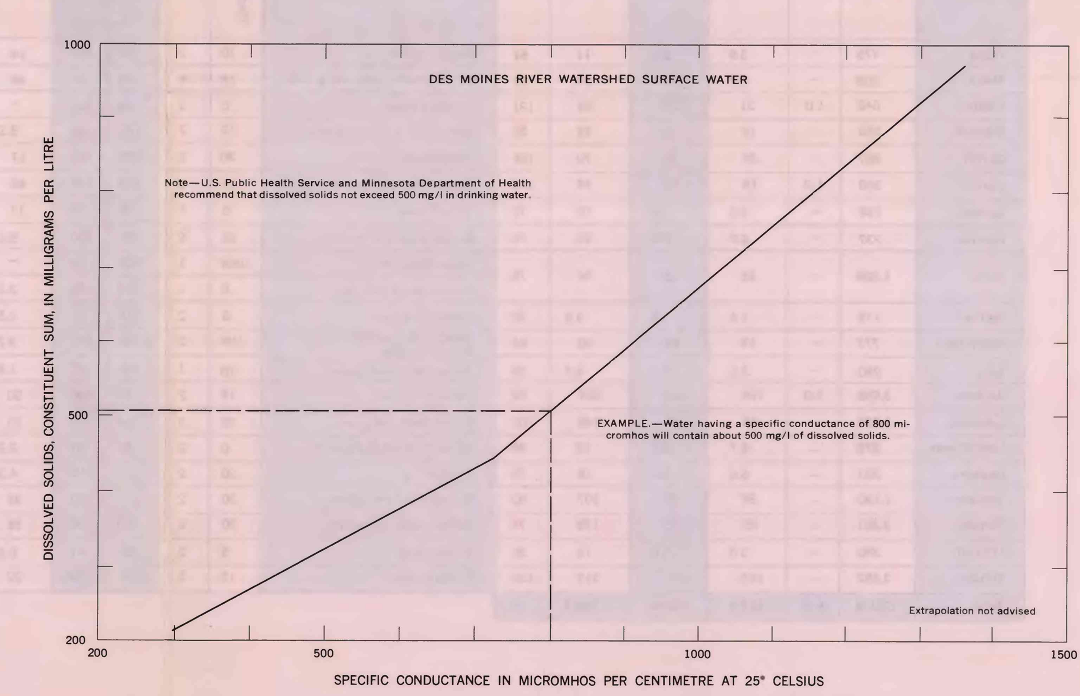
SURFACE-WATER QUALITY AT BASE FLOW IS RELATED TO THE GROUND-WATER LAKE-WATER ENVIRONMENT OF THE WATERSHED.

Dissolved-solids concentrations (500 mg/l and greater) and the cation-anion components in surface water are similar in quantity to those in water from surficial aquifers of the watershed. Dominant ions found in the surface water and aquifer water are calcium, magnesium, sulfate, and bicarbonate. The water in tributary streams draining sand and gravel deposits and the water in lakes usually contain less dissolved solids than streams draining poorly leached glacial tills. Municipal waste disposal raises concentrations of sodium plus potassium and chloride plus nitrate at sampling sites C *and* E*. Adequate softening of this water requires techniques for satisfactory removal of noncarbonate and carbonate hardness.*

Water in the Des Moines River (main stem), Lime Creek, and Heron Lake outlet acquires its eutrophic (nutrient rich) state at base flow by recycling of nitrogen and phosphorus in shallow lakes of the watershed. Ground-water inflow supplies calcium, magnesium, potassium, and bicarbonates. The nutrients stimulate phytoplankton blooms and buffer pH changes. Silica concentrations (range 3-27 mg/l) derived from clays are adequate to support diatom (dominant phytoplankton) blooms and alkalinity enhances growth of green and blue green algae. Complete utilization of nitrate nitrogen was observed at sampling site E *and almost complete utilization of orthophosphorus at sampling site* A.

Phytoplankton populations in the Des Moines River (main stem) help diminish pollution from waste-disposal effluents. Samples collected at the Iowa border indicate that dissolved-oxygen levels drop below 50 percent saturation only under ice cover when dissolved-oxygen replenishment by aeration and algal output is at a minimum. Only 10 percent of the samples collected contained biochemical oxygen demand in excess of 10 mg/l.

The Des Moines River and shallow lakes of the watershed provide little water-contact-sports recreation. Owing to this, minor consideration is given to the sanitary significance of indicator organisms. Minnesota Pollution Control Agency has collected indicator-organism samples from the Des Moines River at the Iowa border and upstream from Lime Creek. Results of this sampling show that only 20 percent of the fecal coliform analyses exceed 500 most probable number while 80 percent of the total coliform analyses exceed 1,000 most probable number. This would indicate that the larger mass of coliform organisms in this stream are of the nonfecal group, which do not impair sanitary conditions in water.



ESTIMATES OF DISSOLVED SOLIDS IN SURFACE WATER CAN BE MADE FROM MEASUREMENT OF SPECIFIC CONDUCTANCE AND USE OF THE RELATIONSHIP IN THE GRAPH.

MAXIMUM, MINIMUM, AND MEAN CONCENTRATIONS OF SELECTED CONSTITUENTS INDICATE EXPECTED LONG-TERM WATER QUALITY VARIATIONS IN THE DES MOINES RIVER AT JACKSON

Des Moines River at Jackson, Water years 1968-74. 17 samples	Dissolved solids (mg/l)	Hardness as calcium carbonate $CaCO_3$ (mg/l) Total	Noncarbonate	Nitrates (NO_3) (mg/l)	Total phosphorus (P) (mg/l)
Maximum	976	590	400	18	0.85
Minimum	362	270	120	0.3	.11
Mean	596	440	230	6.1	.37

Base from U.S. Geological Survey 1:250,000 series: Fairmont, 1954, and New Ulm, 1953, Minn.; Sioux Falls, 1955 and Watertown, 1953, S. Dakota

Interior—Geological Survey, Reston, Va.—1976—W76109

WATER RESOURCES OF THE DES MOINES RIVER WATERSHED, SOUTHWESTERN MINNESOTA

By
H. W. Anderson, Jr., W. L. Broussard, D. F. Farrell, and M. F. Hult

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